PET COKE TEST BURN REPORT

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Executive Summary

The Intermountain Power Project is considering entering into a joint venture with Radian International, Austin, Texas, on a project that would convert the operation of the Intermountain Generating Station (IGS) to produce fertilizer grade ammonium sulfate as a by-product of the flue gas desulfurization scrubbers. A major factor in the project is the use of petroleum coke (pet coke) as a boiler fuel. The pet coke would be blended using a ratio of 20% pet coke - 80% coal on a BTU basis. The high sulfur content inherent in pet coke is essential for the success of the project. The sulfur content in the fuel determines the amount of ammonium sulfate produced in the scrubber.

In December 1999, a preliminary burn of one unit train of pet coke was completed in IGS Unit 1. This test burn proved the viability of pet coke as a boiler fuel, however; many serious questions remained that required a second test burn to answer. The most pressing question was the effect of pet coke on stack NO_x emissions. Any increase in stack NO_x emissions would most likely trigger an environmental review by the state of Utah, Division of Air Quality, which could mandate installation of NO_x control equipment at IGS. The cost of the NO_x control equipment would make the joint venture economically unfeasible at this time. The second test burn was completed in two phases. The first phase was a baseline period with just coal that was used as a comparison with the second phase with the pet coke-coal blend.

This test burn clearly showed that NO_x emissions would increase with the pet coke purchased for this test from a refinery in California. The emissions were minimized by adjusting air flow distribution in the boiler but, it still exceeded the baseline emission rate. The increased NO_x emissions were probably caused by increased levels of nitrogen in the pet coke but, it is unknown if pet coke with a lower nitrogen content will reduce NO_x emissions. Other pet coke parameters, independent of the nitrogen content, may be dominating the conversion of nitrogen to NO_x.

Sulfur Dioxide (SO_2) emissions are also a concern with pet coke because of the high sulfur content. This test did very little to prove the viability of the scrubber to produce ammonium sulfate or to maintain stack SO_2 emissions. This can only be tested by converting one scrubber module to operate with ammonia as the reagent instead of the limestone normally used. The first test burn revealed that some flue gas is passing through the scrubber modules without contacting the reagent sprays and this test verified that conclusion. Approximately 4% of the flue gas is "sneaking" up the module walls without any reduction in sulfur content. This problem can be corrected by installing a shelf around the module perimeter to direct airflow into the middle of the module.

This test did indicate that pet coke can be unloaded and reclaimed without excessive fugitive dust emissions. Some problems were experienced during unloading that will have to be resolved before pet coke can be used on a regular basis. Blending with the rotary plow feeders in the coal yard was reasonably accurate but, some physical separation between the coal and pet coke is needed.

Section I - Introduction and Objectives

We are currently investigating the feasibility of entering into a joint venture with Radian to convert the operation of the scrubber to produce marketable quality ammonium sulfate as a by-product of power generation. The ammonium sulfate could be sold as a fertilizer to be used in the western United States. The economics of this project requires burning petroleum coke (pet coke) in a low percentage (20% on a btu/basis) in the boiler to increase the amount of sulfur dioxide (SO_2) in the flue gas. A previous one train test burn of pet coke was completed in December 1999. This test burn proved the viability of blending pet coke with coal on-site and combustion in our boiler. A second test burn was held in May-June 2000 to further determine the viability of burning pet coke at IGS.

The first test burn, while answering some questions, left many serious issues unanswered. The second test burn sought to clarify the following issues as outlined below:

NO_X Emissions: The first test burn gave some indication that NO_X emissions levels might increase with pet coke combustion, however, the results were not conclusive. This is a key issue for the continued development of this project. Increased NO_X emissions would likely result in the required addition of new NO_X control equipment to IGS. The cost of NO_X control equipment would outweigh the economic benefit from producing ammonium sulfate in the scrubber, thus making the project unfeasible. Determining the impact of pet coke on NO_X emissions was the primary objective of the second test burn.

Mill Fires: There appeared to be an increase in pyrite box fires during the first test burn. However, no attempt was made to quantify the increase. During the second test burn we monitored the amount of pyrites box fires during both phases of the test so the results could be compared.

Mill Fineness: No information was gathered during the first test on mill fineness. Samples were taken during this test to quantify any changes in fineness.

Pet Coke Roll Back: Observations were noted during the first test that pet coke would roll off of the conveyor belts due to the round shape of some of the particles. Observations were made during this test to determine the extent of this roll back.

Fugitive Dust Emissions: During a wind storm in December, dust was observed coming off of the pet coke pile in larger quantities than from the coal piles. Observations were made during this test to quantify the increased potential for dust generation from pet coke.

Slagging-Fouling: Since this test will be for a longer period, more information can be gathered during this test concerning the slagging-fouling potential of pet coke. Observations were made during the different phases of the test to quantify any changes in slagging and fouling.

Scrubber SO_2 Leaks: Since the use of pet coke will double the amount of SO_2 in the flue gas, there is some concern about how much SO_2 levels will increase in the scrubber building. Measurements were taken during the test to log the SO_2 levels in the building.

Ash Loss-On-Ignition (LOIs): Results of the last test showed that fly ash LOIs increased dramatically with the use of pet coke. Further measurements were taken during this test to verify the results. .

Section II - Description of Test Methods and Procedures

1.0 Test Outline

This test consisted of two parts as described below:

Phase 1 - Baseline with Coal: This phase of the test established baseline numbers for comparison with the period when pet coke was burned. This phase of the test lasted 14 days and operation of Unit 1 was basically normal operation. Unit load was dictated by the Energy Control Center.

Phase 2 - Pet Coke Combustion: Pet coke introduced into Unit 1 on May 30 and continued until it was consumed, around June 17, 2000. A total of 24,114 tons of pet coke was burned during this test. The unit was operated as close as possible to that during Phase 1 at first, however, when NO_X emissions increased some tuning was done to reduce the levels.

2.0 Coal Handling Operation

2.1 Pet Coke Delivery and Storage

The pet coke was received in a bottom dump unit train and was unloaded in the same manner as coal. There were three unit trains of pet coke for this test. Two of the trains were 100 car trains (88 tons each) and the last was an 84 car train. After unloading the second train, 16 cars were removed from the train and stored on site. They were picked up again after the final train was unloaded. Samples were taken using the as-received sampling system. No pet coke was sent directly to the units at the time of unloading. The pet coke was stacked on the north end of the reclaim tunnel over Zone 1 (RPF 7A). This zone was cleared of coal to its natural angle of repose prior to receiving the shipment of pet coke.

2.2 Reclaim and Blending

RPF 7A was used to reclaim the pet coke and either RPF 7D or 7B to reclaim the coal. Blending was done according to Figure II-1. The blending was started by establishing coal flow to the appropriate tonnage and then adding pet coke until the desired total tonnage was achieved. This ensured that the percentage of pet coke was not exceeded. RPF 7A was temporarily modified to allow flow rates down to approximately 150 TPH.

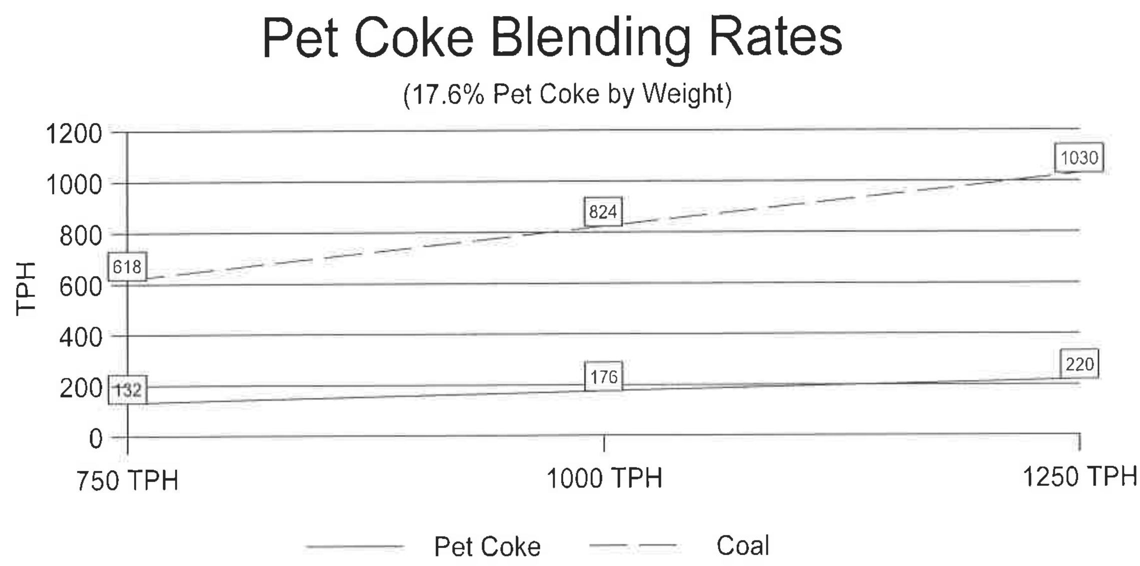

Figure II-1

3.0 Unit Operation

3.1 Baseline Testing

Maintaining consistent operating philosophy and methods was central to ensuring the validity of the test. This was accomplished by having Jon Finlinson, Assistant Superintendent of Operations, coordinate operating philosophy at the beginning of each shift during the test. Also, Unit Operators were not rotated between the units during the 4-week period of the test. Unless constrained by personnel/equipment safety issues or curtailment of generating capability, Operations made every effort to control the following parameters within the specified limits:

- Removed air and coal biases from all pulverizers unless immediately required for stable operation.

- Maintained as consistent a sootblowing schedule as possible around the clock. Specialized sootblowing was based upon the same operating philosophy (i.e., consistency in controllable parameter vs. minimization). The key targets were furnace exit gas temperature and convection pass gas temperature.

- Excess oxygen was tuned for both tests to maximize efficiency and minimize NO_X emissions.

- All equipment, including bias dampers, were operated in automatic mode as far as possible throughout the baseline and pet coke testing periods.

3.2 Pet Coke Testing

Any adjustments to unit operating parameters required upon introduction of pet coke into the coal feed were logged and monitored. Unless specifically identifed within this plan, all operating parameters during the pet coke test burn were maintained as close to baseline testing levels as possible.

3.3 Test Preparations

Prior to the start of baseline testing, the following items were completed to ensure uninterrupted integrity of operation throughout the baseline and testing periods:

1. Preventive maintenance overhaul of the as-fired sampler and cutter assembly.

2. Detailed online inspection of all pulverizers to ensure integrity of key components.

3. Calibration/maintenance on all steam generator O_2 probes.

4. Identification of any feeder totalizer discrepancies (Engineering Services) and calibration of the associated feeders.

5. Ensured all flame scanners were operational with good discrimination and strong signal.

6. Completed one full cycle of sootblowing immediately prior to start of baseline test and pet coke testing.

7. Completed internal visual inspection of all pulverizer pyrite hoppers looking for any indication of oily or tar type substance.

8. Computer Services group performed a routine scan of all power block field inputs to plant data acquisition system to help ensure all essential equipment performance parameters were logged by the PI system throughout the testing period.

9. Bias dampers were checked to ensure proper operation.

10. Trending charts within the plant data acquisition system were developed to monitor and log several operating parameters of specific interest throughout the baseline and pet coke testing sequence. They included:

- Boiler exit gas, O_2 bias, and setpoint
- Bias dampers, positions, and setpoints
- Main steam temperatures
- Reheat temperatures
- Superheat attemperator flow
- Pulverizer air and fuel bias
- Primary air pressure
- Furnace exit gas temperature
- Economizer exit gas temperature
- Pulverizer motor amperage
- Pulverizer differential
- Primary air temperature at each operating pulverizer
- Pulverizer outlet temperature
- Secondary air inlet temperature

4.0 AQCS Operation

Our existing requirement for $S0_2$ emissions was 0.15 lbs/MBTU. Last year the average $S0_2$ emission was 0.07 lbs/MBTU and approximately 93% removal. The addition of the pet coke more than doubled the amount of $S0_2$ entering the scrubber. For this test, we tried to maintain the emissions as low as possible by increasing the removal efficiency. This was accomplished through the following method:

4.1 Sodium Formate as a Scrubber Additive

Buffering agents have been used for years to improve the efficiency of wet limestone scrubbers. For this test, we used sodium formate as the buffering agent. The sodium formate came as a dry crystalline material that was delivered in approximately one ton super sacks.

For efficient operation, the sodium formate should be present in the reaction tanks at a concentration of approximately 1130 ppm. An initial charge of sodium formate was added directly to the reaction tanks and was maintained by adding sodium formate to the Unit 1 Limestone Slurry Storage Tank. In the first pet coke test burn, we learned that pretreatment sludge inhibits the reaction of the sodium formate in the scrubber so it was not used during this test.

Initial Reaction Tank Charge: Hours before starting to burn pet coke, the sodium formate was added directly to the scrubber reaction tanks of the vessels in-service. Three bags for each in-service module were staged in the lifting bays on each side of the scrubber building. The super sacks of sodium formate were lifted to the top of the reaction tanks with the mixer maintenance cranes. The unloading spouts were positioned over the manholes and the sodium formate was poured directly into the reaction tanks.

Initial Slurry Storage Tank Charge: Before burning pet coke, the slurry storage tank also received an initial charge according to Figure II-2. Since it can only be added in bag increments, it was rounded up or down to an even ton amount. The sacks were added by using the mixer maintenance crane over the storage tank and dumping directly into the tanks similar to the initial charge for the reaction tanks.

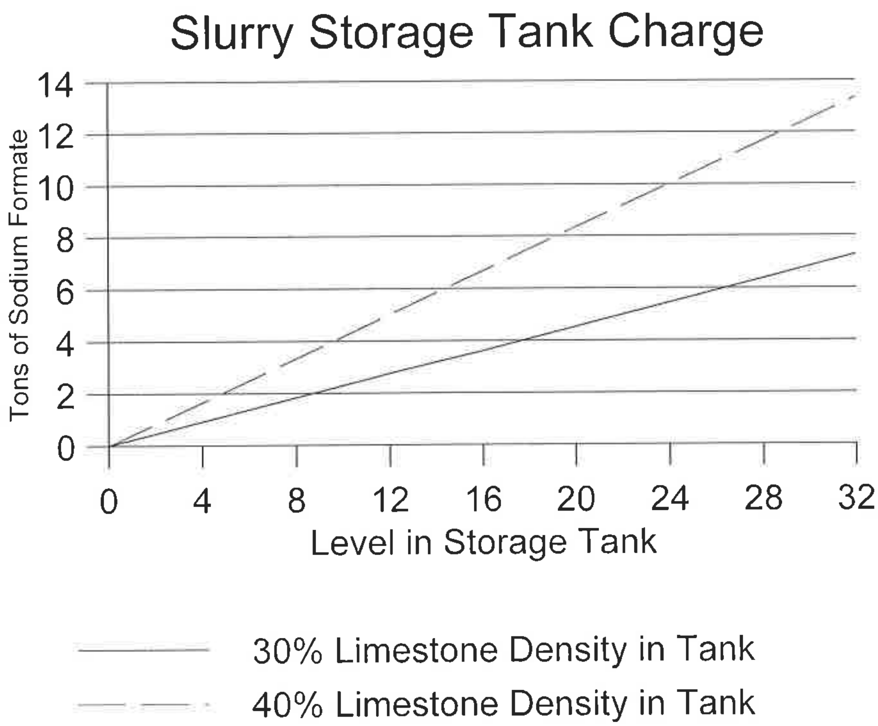

Figure II-2

Charge Maintenance: Since the amount of sulfur entering the scrubber more than doubled, the amount of limestone used also increased by the same amount. The sodium formate was added to the slurry storage for Unit 1 at a rate of 50 lbs/ton of limestone processed. Since the sodium formate can only be added in a one ton bag increment, one bag should be added for every 40 tons processed for Unit 1 (this was changed during the test, see Section IV). This was done evenly throughout the grinding run to prevent dilution of the tank. A buffer capacity test of the limestone slurry storage tank should result in a number between 120 and 170.

The amount of sodium formate in the reaction tanks was monitored twice daily, at the beginning of each shift, by the IPSC lab personnel. They performed a buffer capacity test on one module and the limestone slurry storage tank.

5.0 Sludge Conditioning Operation

It was well proven during the first test burn that pet coke combustion was very detrimental to successful sludge conditioning operation. This was due to the high SO_2 concentrations in the inlet flue gas that inhibits the oxidation in the reaction tanks. This results in a high concentration of sulfite crystals instead of sulfate (gypsum) crystals and sulfite crystals are smaller and much more difficult to de-water on a vacuum filter.

For this test, we avoided this problem by routing the flow from the Unit 1 Scrubber directly to the Waste Water Holding Basin, bypassing all of Sludge Conditioning. This was accomplished by installing a temporary bypass line at the sump pump discharge line into the thickener feed tank. The temporary line discharged into the overflow tank which flows into the Waste Water Holding Basin.

Section III - Unit Operation & NO_X Emissions

1.0 NOx Emissions

1.1 How NO_X is Formed

Combustion of any fossil fuel generates some level of NO_X due to high temperatures and the availability of oxygen and nitrogen from both the air and fuel. There are two common mechanisms of NO_X formation, thermal NO_X and fuel NO_X.

Thermal NO_X refers to the NO_X formed through high temperature oxidation of the nitrogen found in the air. The formation rate is a strong function of temperature as well as the residence time at temperature. Thermal NO_X formation is typically controlled by reducing the peak and average flame temperatures.

The major source of NO_X emissions from coal (and petroleum coke) is the conversion of the fuel bound nitrogen to NO_X during combustion. Laboratory studies[1] indicate that fuel NO_X contributes approximately 80% of the total uncontrolled emissions when firing coal. Nitrogen found in coal is typically bound to the fuel as part of the organic compounds. During combustion, the nitrogen is released as a free radical to ultimately form NO_X. Although it is a major factor in NO_X emissions, only 20-30% of fuel bound nitrogen is converted to NO_X. Conversion of fuel bound nitrogen to NO_X is strongly dependent on the fuel/air stoichiometry but is relatively independent of variation in combustion zone temperature. Therefore, this conversion can be minimized by reducing oxygen availability during the initial stages of combustion.

1.2 Potential for Higher NO_X with Pet Coke

There is no reason to believe that pet coke would result in higher thermal NO_X levels, however, there is a much higher potential for NO_X emissions due to the increased levels of fuel bound nitrogen (see Figure III-1). The pet coke/coal blend had 24% higher content of fuel bound nitrogen as compared to the coal burned in Unit 2 during the same period. Assuming that combustion stoichiometry remained constant and therefore the percentage of fuel bound nitrogen that is converted to NO_X remained constant, the pet coke/coal blend should result in approximately the same increase in NO_X emissions. The NO_X emissions for the baseline period with just coal averaged 0.42 lbs/MBTU. A 24% increase would result in emissions of 0.52 lbs/MBTU. During the first three days of the pet coke burn, the boiler stoichiometry was held close to the same conditions as that of the baseline with just coal. The average NO_X emissions during that period were 0.52

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[1] Steam Its Generation and Use, 46th Edition, Babcock & Wilcox

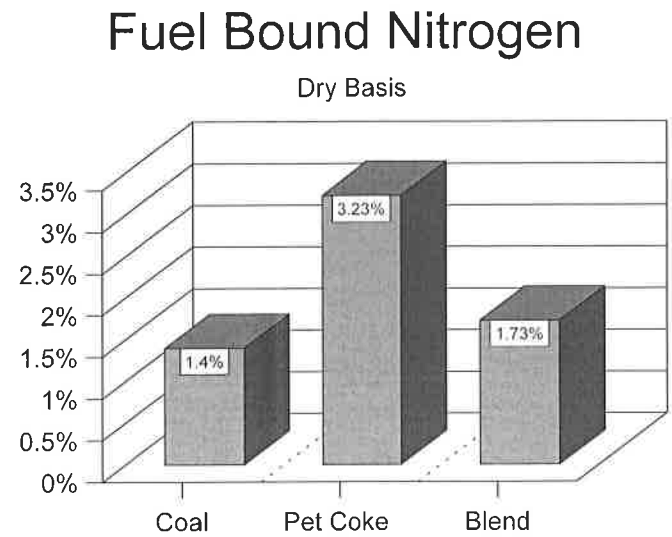

Figure III-1, Percent of Fuel Bound Nitrogen

lbs/MBTU which verifies the assumption that the increase in NO_X was strictly due to fuel bound nitrogen and not thermal NO_X.

However, there is not always a direct correlation between fuel nitrogen content and NO_X generation. Other factors in the pet coke chemistry including volatile species, oxygen, and moisture content might dominate the formation of NO_X during combustion. Therefore, reducing pet coke nitrogen may not provide a corresponding NO_X reduction. This should be remembered when considering a possible test burn with another source of lower nitrogen pet coke.

1.3 Operating Changes to Reduce NO_X

As previously stated, emissions from fuel bound nitrogen can be minimized by reducing oxygen during the initial stages of combustion. During this test, two methods of reducing oxygen at the flame front were utilized. The first (1) method involved opening the secondary air damper to the out-of-service burner row which had the effect of decreasing air to the in-service burners while maintaining total excess oxygen at the furnace exit. This adjustment was made on June 3. The second (2) method completed on June 4, was a reduction in total excess oxygen at the furnace exit from a level around 3% to close to 2%. Both of these changes were done to reduce oxygen in the combustion zone while maintaining sufficient for good combustion. The 2% level was considered a safe setting for test operation, but it would not be viable for long-term operation when normal variations could cause excess oxygen to drop into dangerous levels.

The result of these two changes are demonstrated in Figure III-2, Page 15. Increasing the air to the out-of-service burner row reduced NO_X by approximately 10% and the combined effect of both changes reduced NO_X by 17%. The emission level with both of these changes in effect was 0.43 lbs/MBTU which was just slightly higher than the baseline period of 0.42 lbs/MBTU, however, operation at 2% excess oxygen is not a viable option for long-term operation. Operation with the out-of-service burner damper open is a viable option for some NO_X reduction, but it would not be sufficient for high nitrogen fuels.

1.4 Economic and Operational Impacts of Changes to Reduce NO_X

The most immediate and recognizable effect of removing oxygen from the combustion zone is an increase in unburned fuel in the fly ash. Unburned fuel in fly ash is measured by burning samples of ash in an oven and then weighing the samples after any carbon in the ash has fully oxidized. The results are expressed as a percentage of weight Loss-On-Ignition (LOI). Prior to the introduction of pet coke into the boiler, ash LOIs were typically in the 0.5% range. When pet coke was blended with the coal and burner air stoichiometry remained the same as just coal, ash LOIs increased to approximately 1.42%. When the out-of-service burner row secondary air damper was opened to reduce excess oxygen at the burner, ash LOI's increased to around 1.68% and when excess oxygen at the furnace exit was decreased to 2%, LOI's increased to 2.12% (see Figure III-3, Page 16). LOI represents unburned fuel and added expense to plant operation. Each increase of 1.0% in LOI for both units at IGS represents a loss in unburned fuel equal to $108,276 per year[2].

Increased LOI has made another economic impact to IGS. Currently a large percentage of the fly ash produced at IGS is sold to a contractor for use as a high grade cement additive. The contractor (ISG Resources) has already indicated that burning any amount of pet coke will make the ash unsuitable for use as a cement additive. Last fiscal year (1999-2000) IPP received $1,582,000 from ISG for the flyash they purchased.

Operationally, opening the out-of-service burner row secondary air damper seemed to have little negative impact on unit operation other than increasing ash LOIs. The unit operated stably and none of the operating range for the Operators was removed. However, the same is not true for decreasing excess air at the furnace exit to around 2%. Measuring boiler excess oxygen is inherently difficult and the oxygen meters are frequently giving erroneous readings. Operating at lower excess oxygen levels takes away the margin necessary to maintain stable unit operation. There is some economic benefit of decreased heat rate and fan power savings from operation at lower excess oxygen, but it is not worth considering the savings because of the dangers involved.

1.5 Effect of Pulverizer Configuration on NO_X Emissions

For the majority of the time during this test, pulverizer configuration (which pulverizer

[2] Based on 5.200,000 tons of coal per year, 7.23% ash in blend, 80% flyash, $36 ton/coal

out-of-service) remained constant intentionally to remove some of the variability for establishing baseline conditions. Pulverizer 1F was out-of-service for all of the baseline

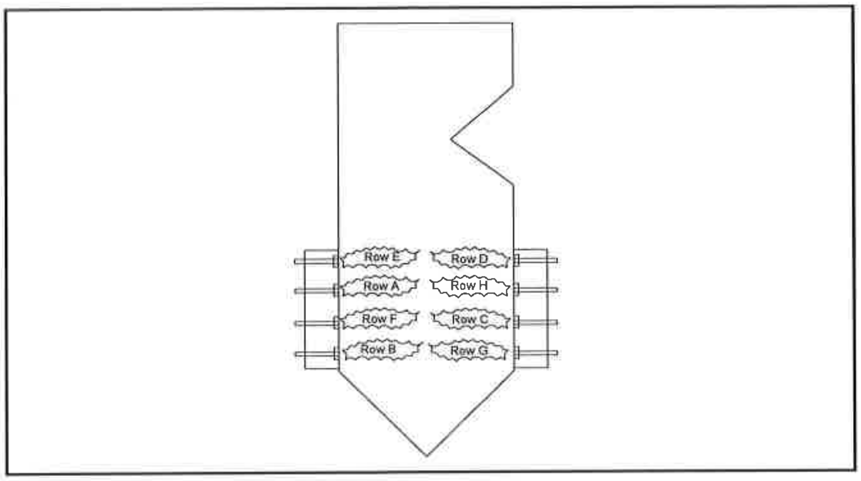

Figure III-5, Boiler Burner Configuration

period and for most of the pet coke burn. Towards the end of the test period, the pulverizer out-of-service was rotated around all of the mills to get an idea of the effect of the different mill configurations. The effect of the different configurations can be seen in Figure III-4, Page 17.

Theoretically, NO_X should be lowest when the upper burners are out-of-service and higher when the lower mills are out-of-service. When an upper burner is out-of-service the cooling air passes through the furnace without passing through another burner flame front. This reduces the contact of nitrogen with oxygen at temperatures sufficient for chemical association. Cooling air from lower burners out-of-service passes through other rows of burners before exiting the furnace. The test results did not clearly support or reject this theory. Due to the limited amount of time available for the test, the runs at different mill configurations were short which made it difficult to average out normal fluctuations in NO_X emissions.

2.0 Pulverizer Fires and Fineness

2.1 Pulverizer Fires

The function of a pulverizer is to grind coal to a form suitable for combustion so it is not surprising that unwanted fires do occasionally occur. These fires, if undetected and uncontrolled, can cause serious damage to pulverizer internals or burners. The most common and least serious location for pulverizer fires is the pyrite box. Pyrite box fires are not as serious because of the low volume of fuel and air. The pyrite box is designed to handle fires and they are easily extinguished by flushing the box with water. The second most likely location is the burner lines. Burner line fires are more serious because large quantities of fuel and air are present and the burner diffuser and pipe can be damaged from the heat. Burner line fires are extinguished by shutting the pulverizer down and starving the fire of oxygen. The most serious type of fire is right in the pulverizer itself where large quantities of fuel are readily available and the potential for an explosion exists.

There is nothing inherent in pet coke that would cause more pulverizer fires than coal. In fact, the low volatility of the pet coke should result in fewer fires than coal. However, during the first test burn, there was some indication that more fires did occur and they were more serious in nature. During this test, more effort was taken to quantify the amount and types of fires that occurred. The results are summarized in the following table:

	# of Pyrites Fires	# of Burner Line Fires	# of Pulverizer Fires
Baseline Period with Coal	8	3	0
Pet Coke-Coal Blend as Fuel	7	1	0

The results of the test support the theory of a similar or lower potential for pulverizer fires with pet coke. This is particularly true with the burner line fires which would be most affected by the lower volatility of the pet coke.

2.2 Pulverizer Fineness

Fuel fineness can affect several factors of unit operation including NO_X formation and ash LOI. The pet coke used for this test had a slightly higher Hardgrove Grindability Index (HGI) than the coal during the same period. It was not expected that we would see a large change in mill fineness with the low percentage of pet coke in the blend, but it was tested anyway just to make sure that it would not be effected. The results indicate that fineness was unchanged with the pet coke blend as summarized below:

	Baseline with Coal	Coal Pet Coke Blend
HGI	43.5	45.7
% Through 200 Mesh	70.60%	69.81%
Total Moisture %	6.69%	6.82%

3.0 Boiler Slagging and Fouling

During the test periods, daily observations were made of the boiler platens and pendants plus burners to look for changes in the appearance and size of the boiler slagging and burner eyebrows. The position of the flame front in relation to the burner wall and the flame appearance were also documented. Three observation ports on both sides of the boiler (15th floor) and four observation ports on both sides of the boiler (14th floor) were used as well as 20 ports to observe the boiler flames were used in the walkdowns. The results showed that slagging and fouling was not any worse when comparing Unit 1 base test and the pet coke burn or when comparing the pet coke burn with Unit 2 operation. It should be noted that Unit 2 had returned from a five week major overhaul the first week in April and Unit 1 had returned from a one week outage the first week in May so both furnaces weren't throughly seasoned. Also, the roughly three week test burn may not be an adequate duration to see the full affects of long-term slagging and fouling. Based on the pet coke ash quantity (around 0.5%), less slagging and fouling was predicted.

Burner eyebrows on some burners grew in size and then fell off. This was a typical observation on both units. The largest ash/slag accumulations were observed on the front lower sections of the secondary superheat intermediates. Up to two feet of ash accumulation was observed around sootblowers IK 29 & 30 and below. All tube banks in this area had the typical honeycomb accumulation on the bottom section where there is a lack of sootblower coverage. The platen sections showed the next largest accumulations. The front section of the secondary superheat outlet also showed up to four (4) inches of ash accumulation. These three areas all showed typical tube-to-tube accumulation within each bank. The back section of the secondary superheat outlet and the reheat outlet bank showed only slight accumulations tube-to-tube as well as front tube accumulation. The amount and properties of the slagging did not appear to change when pet coke was added to the fuel and relative position and appearance of the flame front was unchanged.

Pet Coke Test Burn NOx Emissions

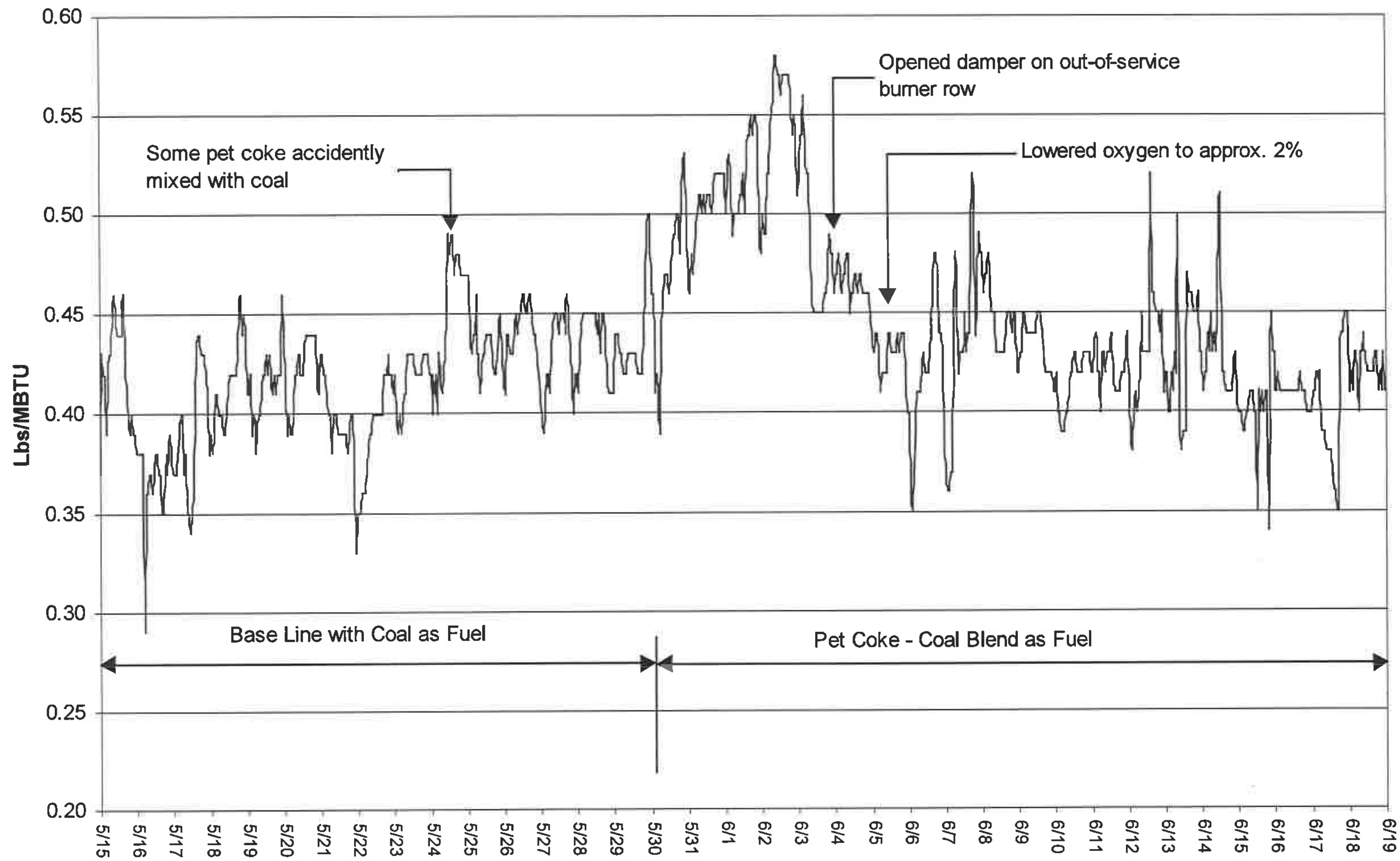

Figure III-2

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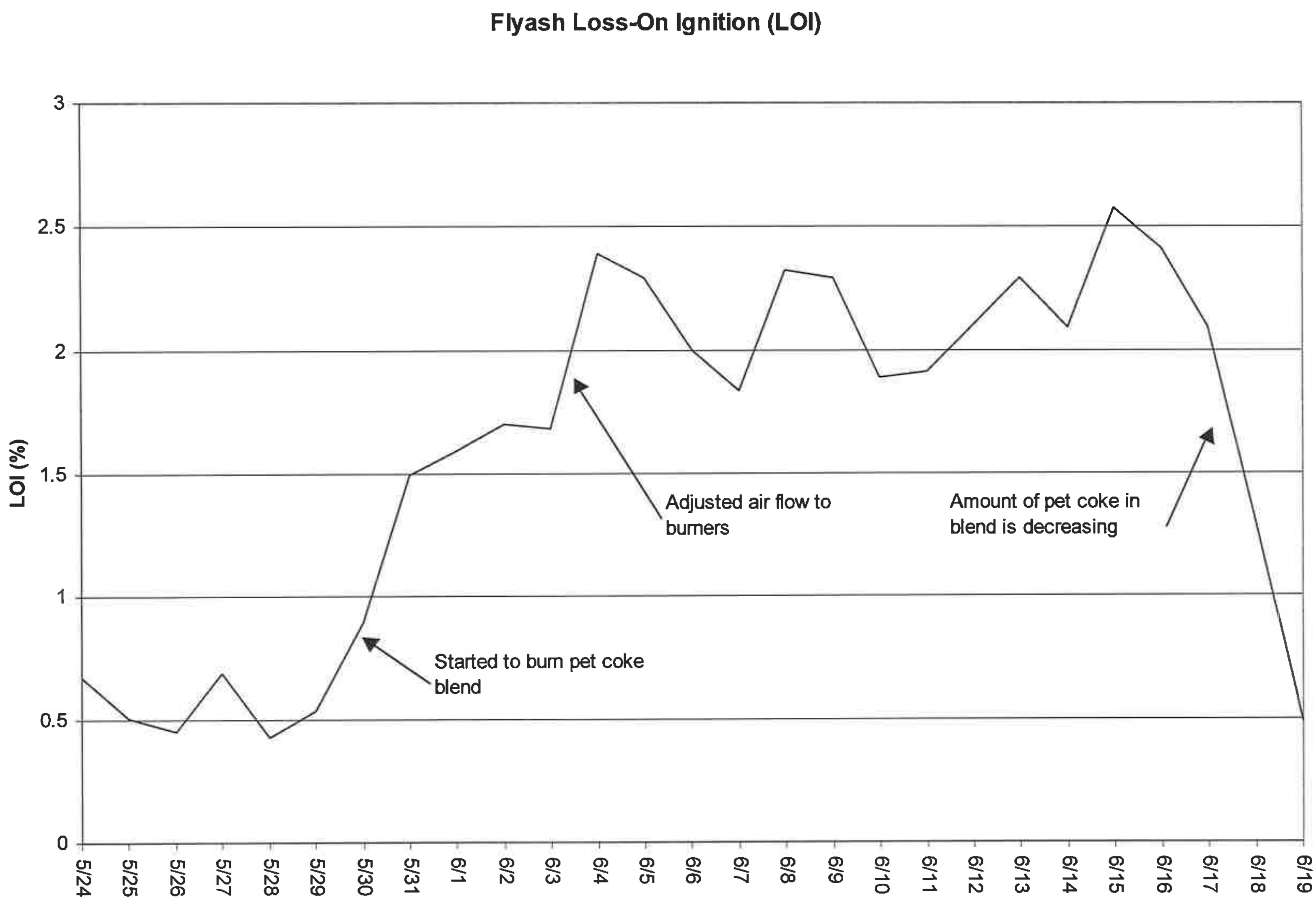

Figure III-3

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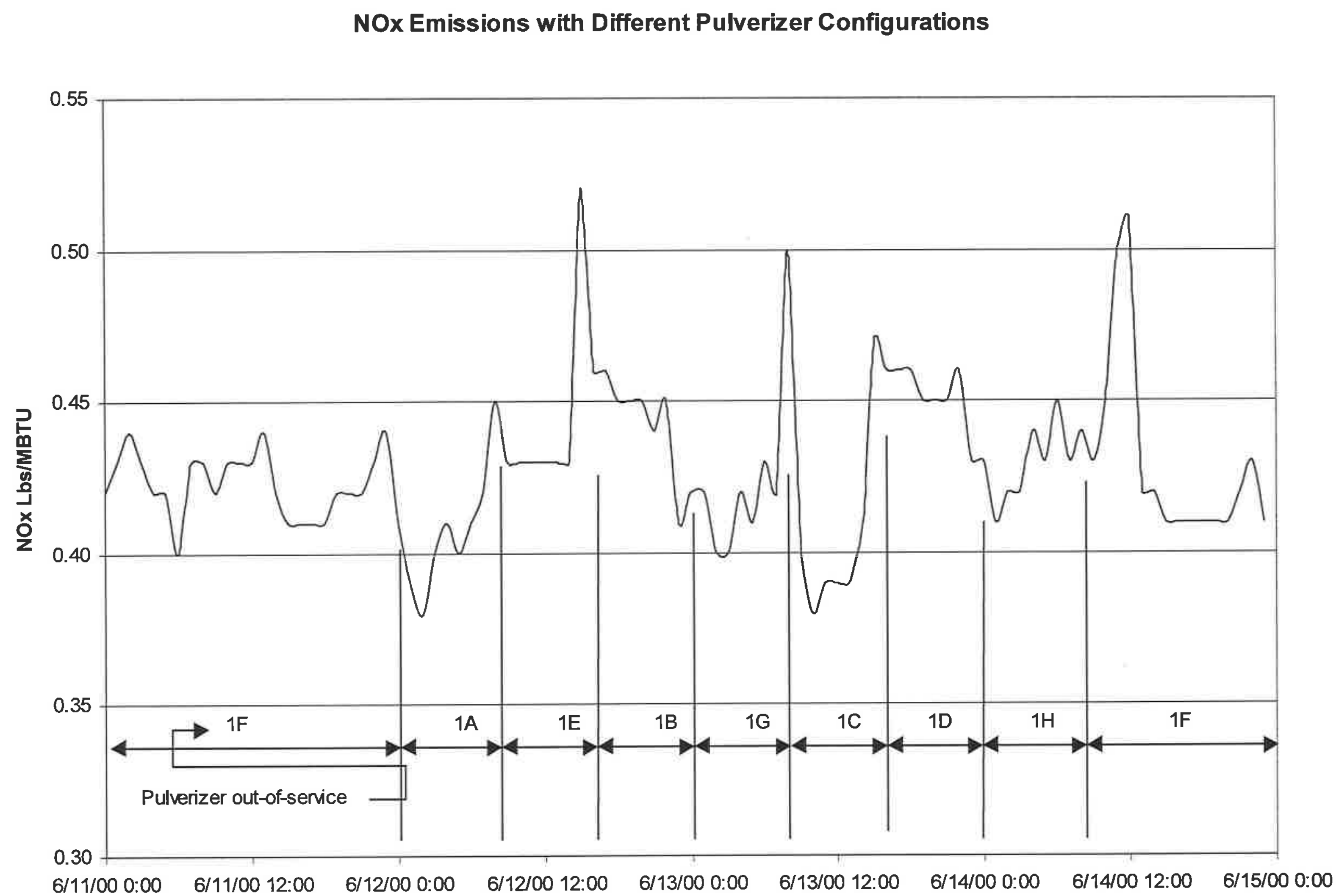

Figure III-4

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Section IV - Scrubber Operation

1.0 Scrubber and Ammonium Sulfate Project

The main impact from burning petroleum coke as a fuel is the much higher content of sulfur-dioxide (SO_2) in the flue gas. Of course, for the joint venture project being considered with Radian, the increased sulfur is desirable and is one of the main reasons pet coke is being considered as a fuel. The increased sulfur means an increase in ammonium sulfate production and more profit from the venture. Environmentally, the increased sulfur in the fuel can only be tolerated as long as SO_2 emissions do not increase out the stack. Since the sulfur content in the fuel will more than double with the addition of pet coke, scrubber removal efficiency will have to improve to compensate. Current scrubber efficiency typically operates around 94-95% removal of SO_2. This means that it will have to increase to around 97-98% to maintain SO_2 emissions at or below historic levels.

If this project proceeds, the entire operation of the scrubber will be modified to produce ammonium sulfate as a by-product instead of the gypsum currently being produced. Ammonia will replace limestone as the reagent, oxidizing air will be injected into the reaction tanks, and the top of the reaction tanks will have to be sealed to control ammonia vapors. In addition, a buffering agent will be added to improve efficiency and increase ammonium sulfate production. Since these modifications are not currently in place, the test burn did very little to disprove or prove the possibility of achieving the required removal efficiencies or the viability of producing ammonium sulfate with the IGS scrubbers. This can only be done by actually modifying a scrubber module to operate with ammonia as the reagent.

During the first pet coke test burn in December 1999, it was determined that removal efficiencies could not be improved by the addition of a buffering agent (sodium formate) alone. After the test burn, it was theorized that the reason for the lack of performance was a problem in the scrubber module that allowed flue gas to pass though the module without coming fully in contact with the reagent sprays. This is referred to as "sneakage" and is most likely taking place around the module walls. Radian has indicated that this is a common problem for scrubber modules designed 20 years ago and it can easily be corrected. They recommend installing a shelf around the inside of the module, just below the spray level, to direct air flow from the wall to the center of the module.

2.0 SO_2 Emissions During Test

This test burn also proved that scrubber removal efficiencies cannot be improved while burning pet coke by the addition of a buffering agent alone (Figure IV-1, Page 22). As in the first test, sodium formate was used as the buffering agent. Even though efficiencies did not improve, the sodium formate was essential to maintain overall emission levels below the current permit requirement of 0.15 lb/MBTU. For the first 15 days of the test just coal was used as the fuel to establish baseline emissions for comparison with the pet coke coal blend. For the baseline period, SO_2 emissions averaged 0.04 lbs/MBTU. During the pet coke-coal blend period, SO_2 emissions averaged 0.10 lbs/MBTU for a 150% increase (see Figure IV-2, Page 23). The results of the baseline period were biased by some pet coke that accidently got mixed with the coal because the two piles were not physically separated. There was also a period during the pet coke burn when pet coke flow was suspended due to problems with the en-masse conveyors. The amount of pet coke in the fuel at any time can easily be determined by monitoring scrubber inlet SO_2 concentrations. At the proper blend of 20% pet coke on a BTU basis the inlet SO_2 reading should be around 850 PPM (see Figure IV-3, Page 24).

In addition to the sodium formate, scrubber module pH was also raised from 5.65 to 5.75 during the test to improve removal efficiency. This was also done during the first test burn and was found to help. The concern with operating at a higher pH is the increased potential for scaling in the reaction tank and piping over long periods of time. For this short test period, the risk was minimal.

Since the sodium formate is added to the scrubber before pet coke is mixed with the coal, there is a short period where efficiency increases from the addition of the buffering agent. If you assume that during that period, the SO_2 that comes in contact with the scrubber sprays is 100% removed, you can estimate that approximately 4% of the entire flue gas flow is "sneaking" past the sprays in the scrubber modules. Resolving this sneakage could possibly be of immediate benefit to IPP. All three scrubber spray levels with their associated pumps now operate to maintain required efficiencies. It is possible that resolving this "sneakage" may allow operation with only two spray levels which would result in a large auxiliary power savings.

3.0 Sodium Formate Usage

Many utilities use an organic acid (e.g., adipic acid, dibasic acid, or formate) to enhance scrubber performance. Sodium formate was added in amounts to maintain about 1100 ppm formate ion in the scrubber liquor. Formate ion increases the capacity of the scrubber liquid to absorb SO_2 by buffering the pH in the absorber. The sodium has no scrubber performance benefit, but neutralizes the formate ion (formic acid) for easier storage and handling. Sodium formate was delivered as dry powder in 1000-kg (2205-lb) bags. Based on the usage from the first test burn, 324,000 lbs (147 bags) of sodium formate was purchased for this test. In addition to the sodium formate purchased, seven bags left from the first test in December 1999, was also available for use.

Bags of sodium formate were added to the limestone slurry tank (10 bags) and to the reaction tanks (3 bags each) to spike the scrubber system with the required level of formate that would be maintained during the test. Personnel in the IPP water lab were trained in a test method to measure buffer capacity of the scrubber liquid. The buffer capacity test gave results in units of milli-equivalents per liter (meq/L). Figure IV-4, Page 25, shows a graph of the buffer capacity correlation for IPP scrubber liquor with known amounts of formate added. The graph was used during the test to estimate formate concentration in the scrubber slurry. Buffer capacity testing of the slurry and reaction tanks during the test period (Figure IV-5, Page 26) indicated a fairly wide range of results, particularly in the slurry tank.

During the first test burn we learned that pretreatment slurry from water treatment could not be used as grinding water because the iron in the sludge reacts with the formate thus reducing its buffering capacity. For this test Operations was very careful not to use any pretreatment sludge in limestone preparation. This resulted in using less sodium formate than what was used during the first test burn. At the start of the test sodium formate was being added at the rate of one bag per 40 tons of limestone processed. On June 2nd, the rate was decreased to one bag per 50 tons processed because the buffer capacity in the reaction tanks was increasing. This resulted in a large amount of sodium formate remaining after the test was completed. Celanese (sodium formate supplier) agreed to purchase the leftover 42 bags at 85% of the original purchase price. This means that a total of 112 bags (246,960 lbs) was used for this test.

4.0 Background SO_2 Levels in Scrubber Building

The IGS scrubbers are somewhat unique because they are completely enclosed by a weather protecting building. This is nice in many ways but can cause some problems if there are any flue gas leaks which could cause SO_2 levels in the building to raise to dangerous levels. This has occurred in the past, IPSC installed a warning system for building evacuation and also instituted a login procedure to monitor scrubber building personnel traffic. Since some leaks always exist, it is not uncommon to have low background levels of SO_2 in the building at all times. There was some concern prior to the test that increasing the SO_2 levels in the inlet duct would result in dangerous background levels in the building. For this reason, SO_2 levels in the building were closely monitored by safety personnel during the test. Fortunately, no increase was noted.

On June 12, CO_2 was detected in high concentrations near Scrubber Module 1C inlet shelf. Since no significant levels of SO_2 was detected, the CO_2 did not appear to be coming from an actual flue gas leak. CO_2 is a by-product of the gypsum formation in the reaction tank, it is possible that it was caused by reaction tank off-gassing and not by a leak. In any event, if the increased CO_2 was caused, for any reason, by the pet coke or sodium formate, the problem will be resolved if the project proceeds, because the top of all reaction tanks will be sealed to prevent ammonia vapors from escaping.

5.0 Effects of Petroleum Coke on Fabric Filter

During the first test burn of petroleum coke, no negative impacts were noted in the fabric filter due to the petroleum coke. The same was noted during this test, baghouse differential pressures did not change significantly and operation appeared to be normal. Several weeks after the test was completed in mid-July, Maintenance noted that the equalizing valves and lines on several flyash feeders were plugged with a dark colored ash. A sample of the ash was analyzed for LOI to see if it was close to the same as the LOI measured from samples taken during the test burn. The ash plugging the lines had an LOI of 33%, well above the 2.5% measured during the test burn. It is unclear if the ash plugging the lines is directly related to the test burn. There is some suspicion because no lines have plugged on Unit 2 which did not use any pet coke as fuel. More testing may be required in this area if the decision is made to have another test burn.

Scrubber Removal Efficiencies

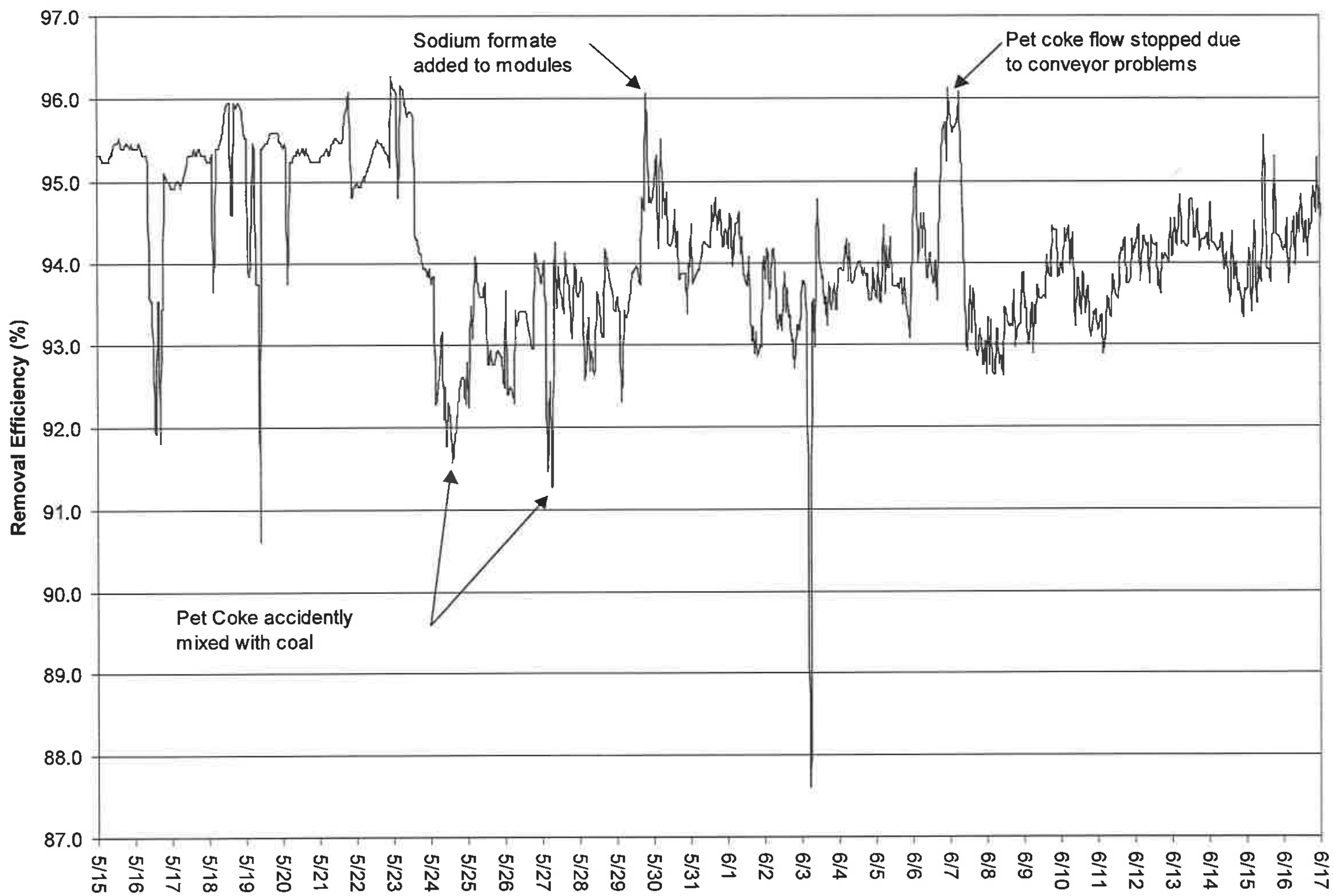

Figure IV-1

Scrubber SO2 Emissions

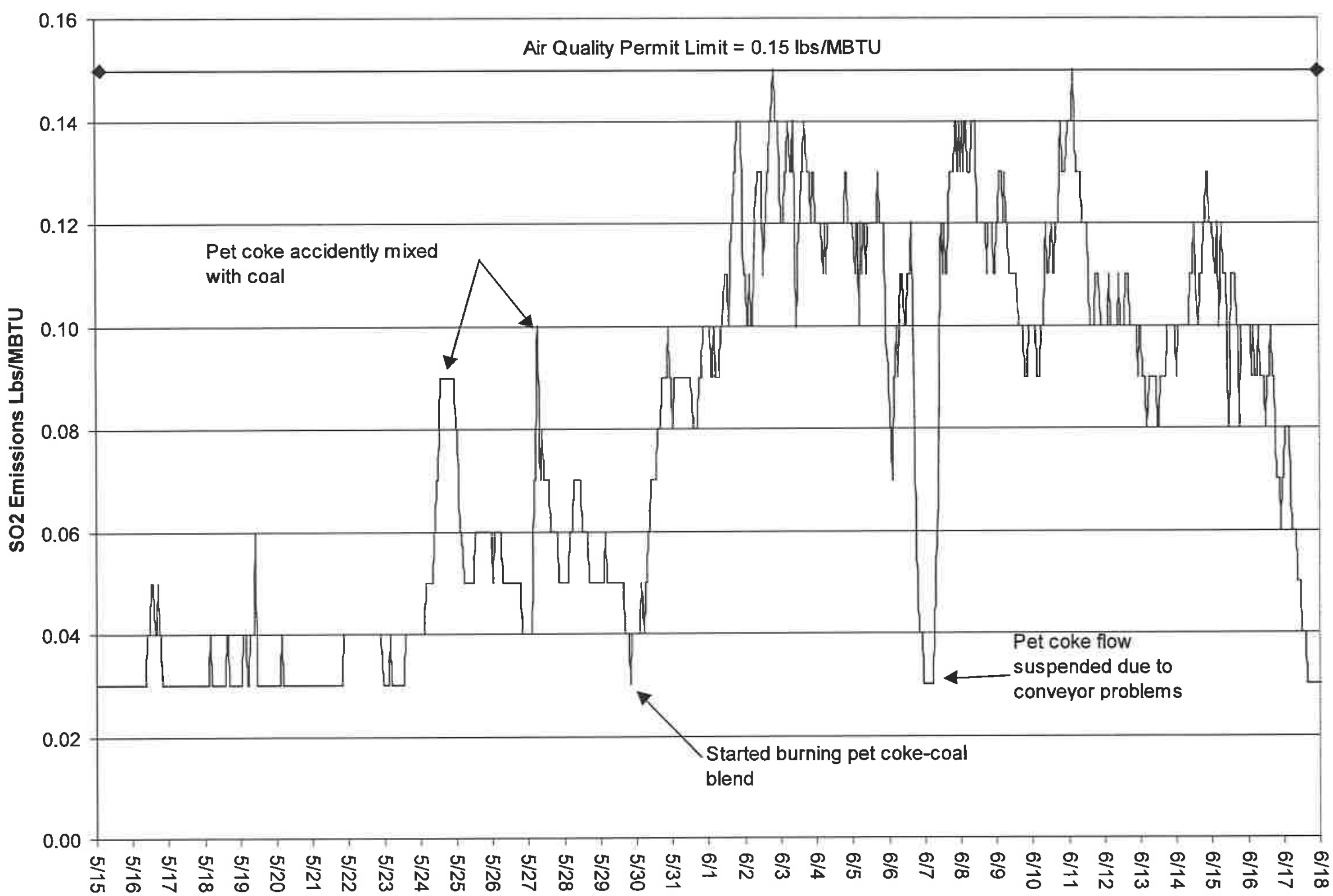

Figure IV-2

Scrubber Inlet and Outlet SO2 Concentrations

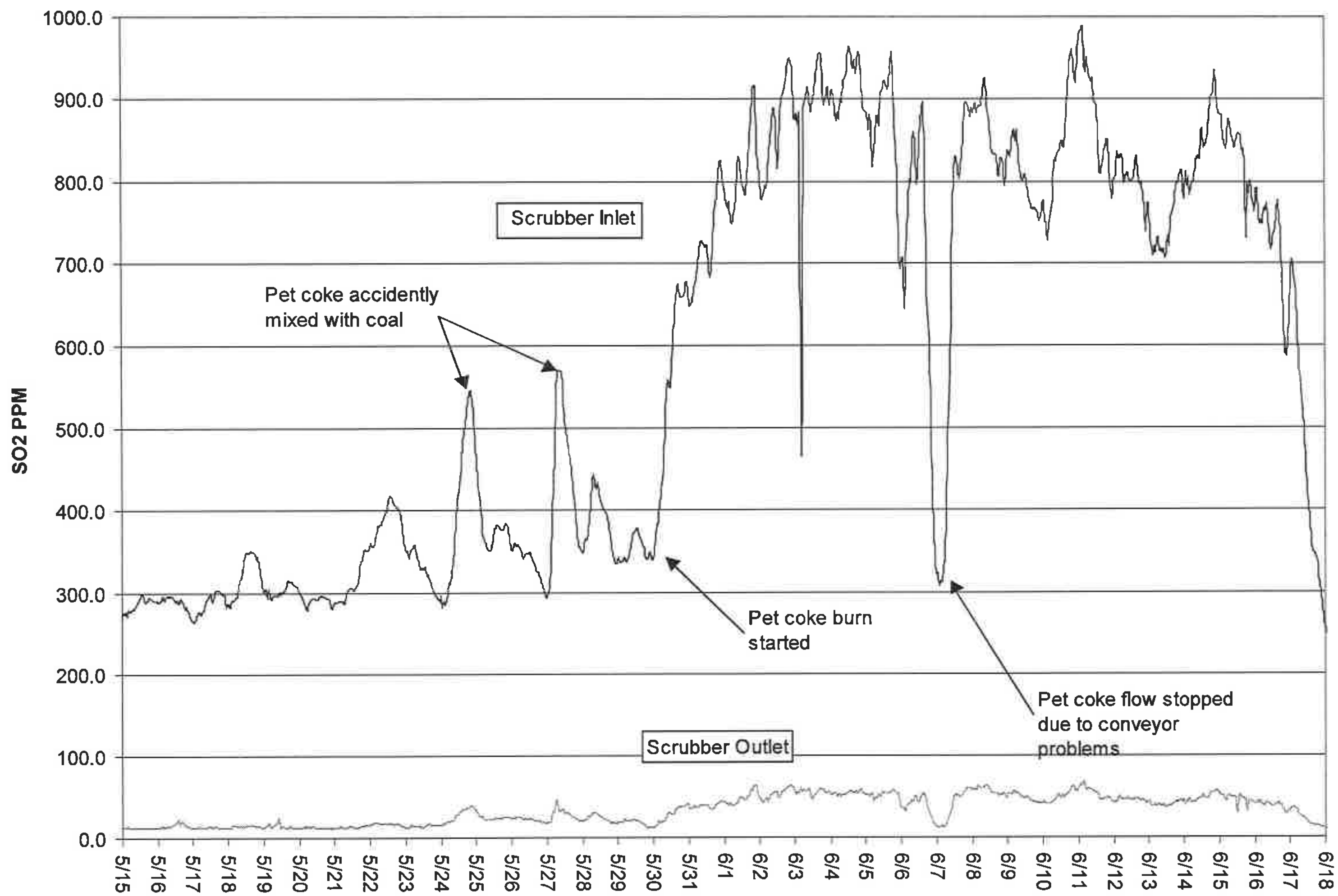

Figure IV-3

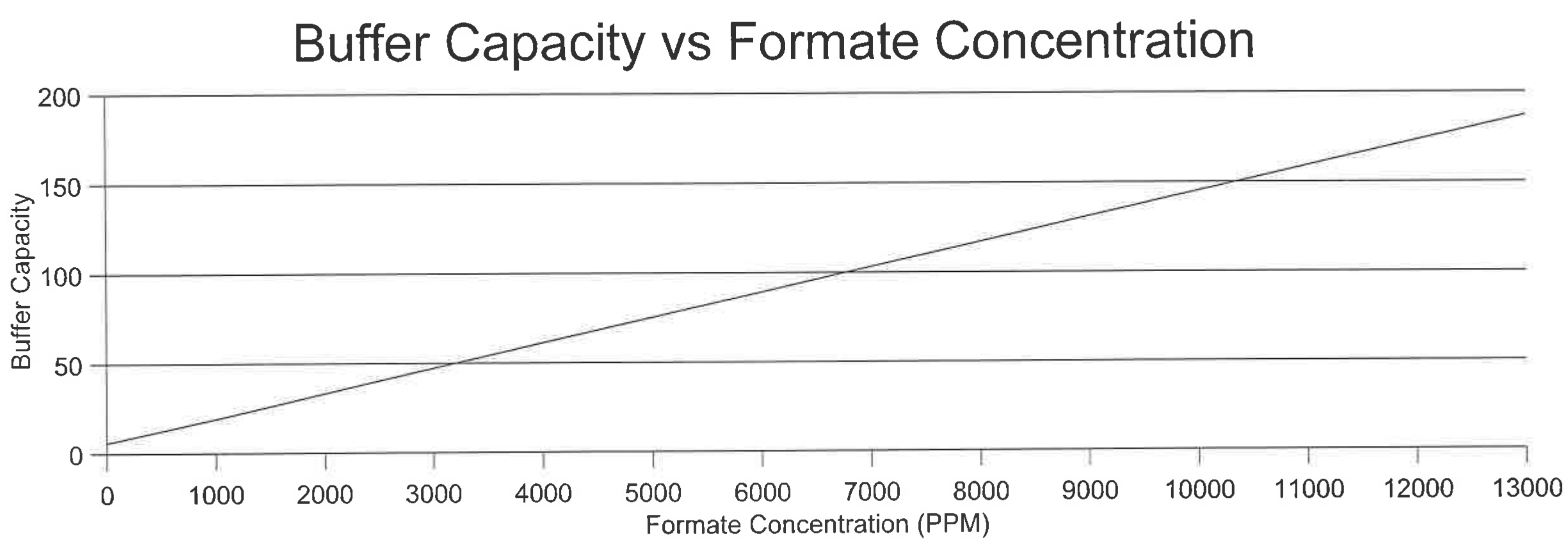
Buffer Capacity vs Formate Concentration
Buffer Capacity
200
150
100
50
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
Formate Concentration (PPM)

Figure IV-4

Scrubber Reaction Tank Buffer Capacity

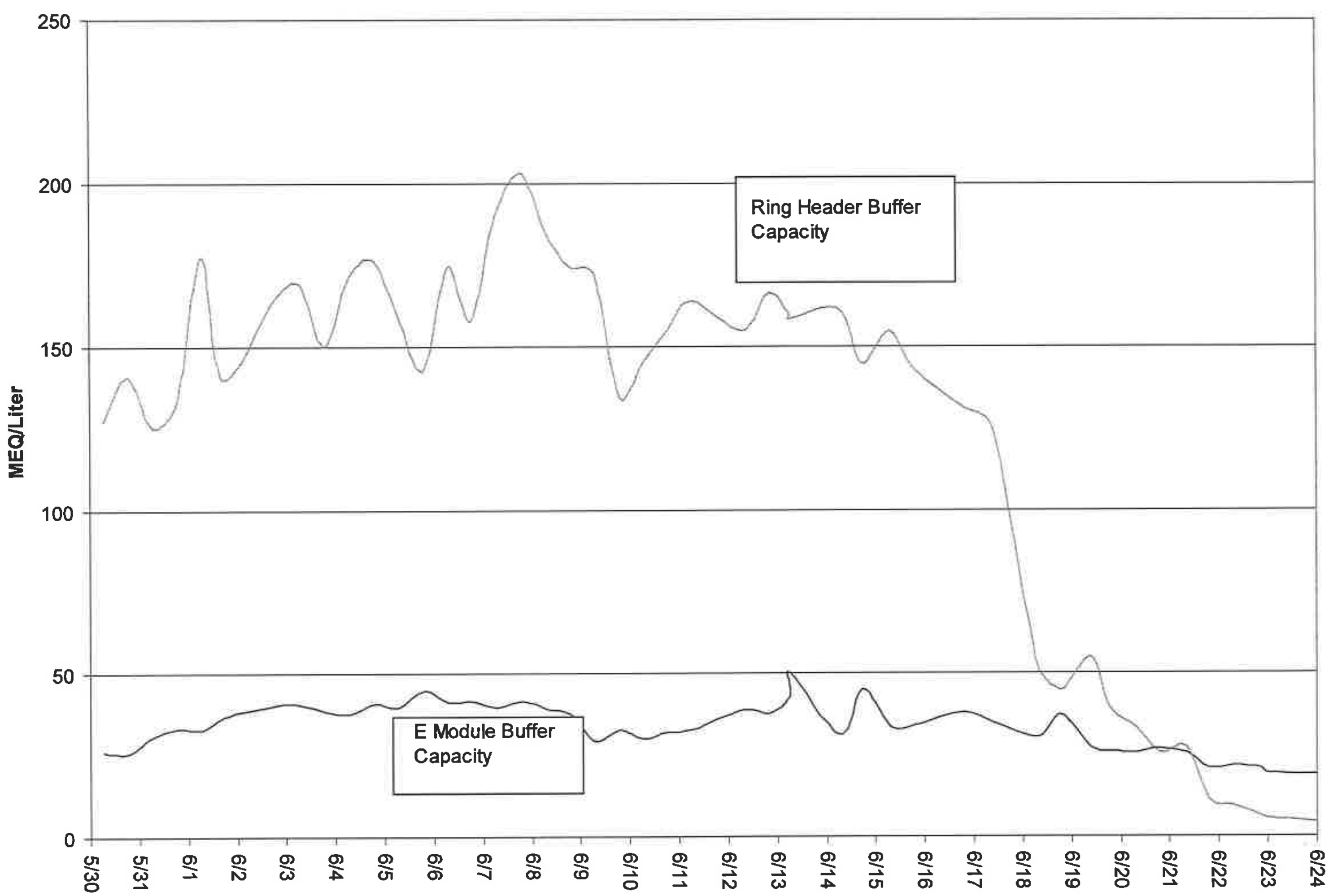

Figure IV-5

Section V - Material Handling

1.0 Unloading Concerns

1.1 Thawshed Damage

The unloading of the first pet coke train on May 11, 2000, was complicated by damage to the thawshed. The train was being run through the unloading building without dumping to get a loaded weight first when the air hoses which were dragging and the low suspended brake rods hit some of the undercar heaters and severely damaged them. A heater on the west end of the thawshed became stuck on a car and was pulled across the remaining heaters in the direction of travel pulling others loose. Approximately 30 heaters were damaged with 22 of the 30 totally destroyed. The train was delayed for 2 hours to cleanup the heaters and clear the path to continue weighing and unloading. The Union Pacific was notified and sent a claims adjustor who was onsite the next morning to observe the damage. The initial repairs have been made to the salvageable heaters and wiring and additional heaters are on order. The repairs including replacement heaters and the labor will cost approximately $50,000. The subsequent trains of pet coke were unloaded with no other thaw shed problems; the lower heaters were no longer in place.

1.2 Pet Coke Sticking in Rail Cars

Unloading the pet coke for this test was similar to unloading frozen coal in the winter. The pet coke was packed tight in the cars due to the high percentage of fines in the mixture. All three trains were dripping water when they arrived onsite which would contribute to unloading problems in cold weather. Approximately 50% of the cars dumped clean, the other 50% of the cars on all three trains had some pet coke hang up in the ends and corners which did come clean after the doors were cycled or the cars were bumped. Between 12 and 20 cars on each train retained 25% or more and required significant effort to unload; cycling the doors, pounding on the cars, rodding the pet coke and bumping of the cars by the power units were techniques used to assist in emptying the cars. Four cars were unable to be unloaded on the first train using the above techniques and were sent back loaded. Six cars were unable to be unloaded on the second train, three were sent back loaded, three were set out onsite when the car numbers were reduced for the last train. All the cars were unloaded and cleaned out on the last train using fire hoses.

1.3 Unloading Difficulties With UP Cars

Unloading the pet coke trains was complicated by the type and condition of the cars supplied by Union Pacific. The cars were made of steel, combination bottom dump rapid discharge and rotary dump. The condition of the slopes and interior surface indicated they had not been used for anything for awhile, the sides were rusty and corroded. They had not been used as a bottom dump system for sometime, which was apparent by the lack of hoses and the condition of the dump air system. When the first pet coke train arrived, twenty-two cars had missing or damaged dump air hoses. The Union Pacific was notified of the missing hoses and requested to make repairs. A UP car crew was dispatched from Provo to come onsite and install the missing and repair the damaged hoses. Waiting for car repairs caused a twelve-hour delay. After the car hose repairs were made and the unloading began, various dump system problems were encountered, air leaks, and closed air valves required attention before unloading could continue. Twenty-five cars were either missing the shoe which electronically activates the dumping mechanism, or the electronic dumping mechanism was inoperative for some other unknown reason; these cars required manual activation of the dump mechanism. Similar problems were experienced on the second and third trains even though the hoses were intact. Each train had numerous hoses unhooked and valves closed which required attention. Due to the problems with the cars, as well as the material sticking mentioned previously, the actual unloading time of the pet coke trains was approximately six hours instead of the two hours or less normally required for coal unloading.

1.4 Pet Coke Roll Back on Conveyor Belts

The pet coke received for this test did not roll back down the conveyor belts or stack out piles. The material configuration was not round or formed into balls. The shape was irregular and consistent with crushed coal. The pet coke handled and stacked similar to crushed coal.

1.5 Fugitive Dust

Some fugitive dust was observed while unloading and reclaiming pet coke. During train unloading fugitive dust was primarily observed at the train unloading hopper and the stacker discharge chute. During reclaim and transfer operation fines were observed carrying over on the head pulley of belt seven. This required adjustment of the belt scraper which resolved the problem. No dusting was observed at the transfer points and chutes inside the transfer buildings. The quantity of dusting was similar to the quantity of dust observed when unloading a coal train or reclaiming and transferring coal. Observation of dusting was performed by qualified environmental technicians with calibrated eyeballs who use EPA Method Nine to quantify dust. The observation sheets are attached. The dust was generally controlled by the dust collectors and the dust suppression system. When pet coke was stacked out wet due to excess water from the rail car cleaning or the dust suppression system a crust was formed on the pile which was beneficial for prohibiting future dusting from the pile. The existing IPSC Fugitive Dust Plan and dust control equipment will probably be sufficient to control pet coke fugitive dust subject to approval by the State regulatory agencies.

2.0 Reclaim and Blending

2.1 Accuracy of Blending

The desired blend of pet coke and coal for the testing period was 20% pet coke to 80% coal on a btu basis. Once the test was underway the actual sampled blend varied from 16.3 % to 24.8% pet coke. The average of the blend from 6/1 to 6/15 was 20.74% (See Figure V-1, Page 30). This indicates that long-term blending of coal with the rotary plows is feasible with a reasonble degree of accuracy for the amount of material processed. By analyzing the properties of the blended fuel in the IPSC Laboratory, adjustments were made almost daily to insure as accurate a blend as possible.

Some problems were experienced initially obtaining the proper blend due to the range of control on the rotary plow feeders supplying coal and pet coke on Conveyor 7. The original control setting moved the demand and speed 5% for each push of the button on the controller. The setting was changed to give a 2.5% change in demand and speed for each push of the button allowing finer control enabling the operators to dial in the blend more accurately. As the size of the pet coke pile decreased the feeder began to create a hole at each end while the feeder was turning. To ensure the feeder did not run empty and create a problem with the blend an operator was assigned to watch the feeder locally and make sure it was turned before running into the empty areas. This required a dedicated Operator to watch the feeder who was unable to perform other functions while the pet coke was being reclaimed. This problem would be eliminated if pet coke was delivered continuously and the pile was maintained throughout the length of plow travel.

2.2 Lack of Physical Separation Between Coal and Pet Coke

Lack of physical separation between the coal and the pet coke created problems, some before the test, and some during the test. We had two incidents of pet coke being introduced to the units before the test was scheduled to begin. This caused some concerns with SO_2 emissions in the scrubber though no limits were exceeded. The feeder reclaiming coal next to the pet coke pile reclaimed pet coke after a physical stop had been added to prevent it from reaching the pet coke. The pet coke was actually spread beyond the area the physical block had been placed to prevent the plow from reaching. The block was repositioned to ensure the coal feeder could not reclaim pet coke. During the testing period, a coal train was unloading some coal which was inadvertently stacked out beyond the designated coal area and onto the pet coke pile. The blend was diluted for a period of time due to this incident. To maintain blending accuracy and integrity on a continuous basis a physical separation such as a retaining wall between coal and pet coke or stacking pet coke in a separate location away from the coal with a separate reclaim system would be necessary.

Pet Coke Blend Accuracy

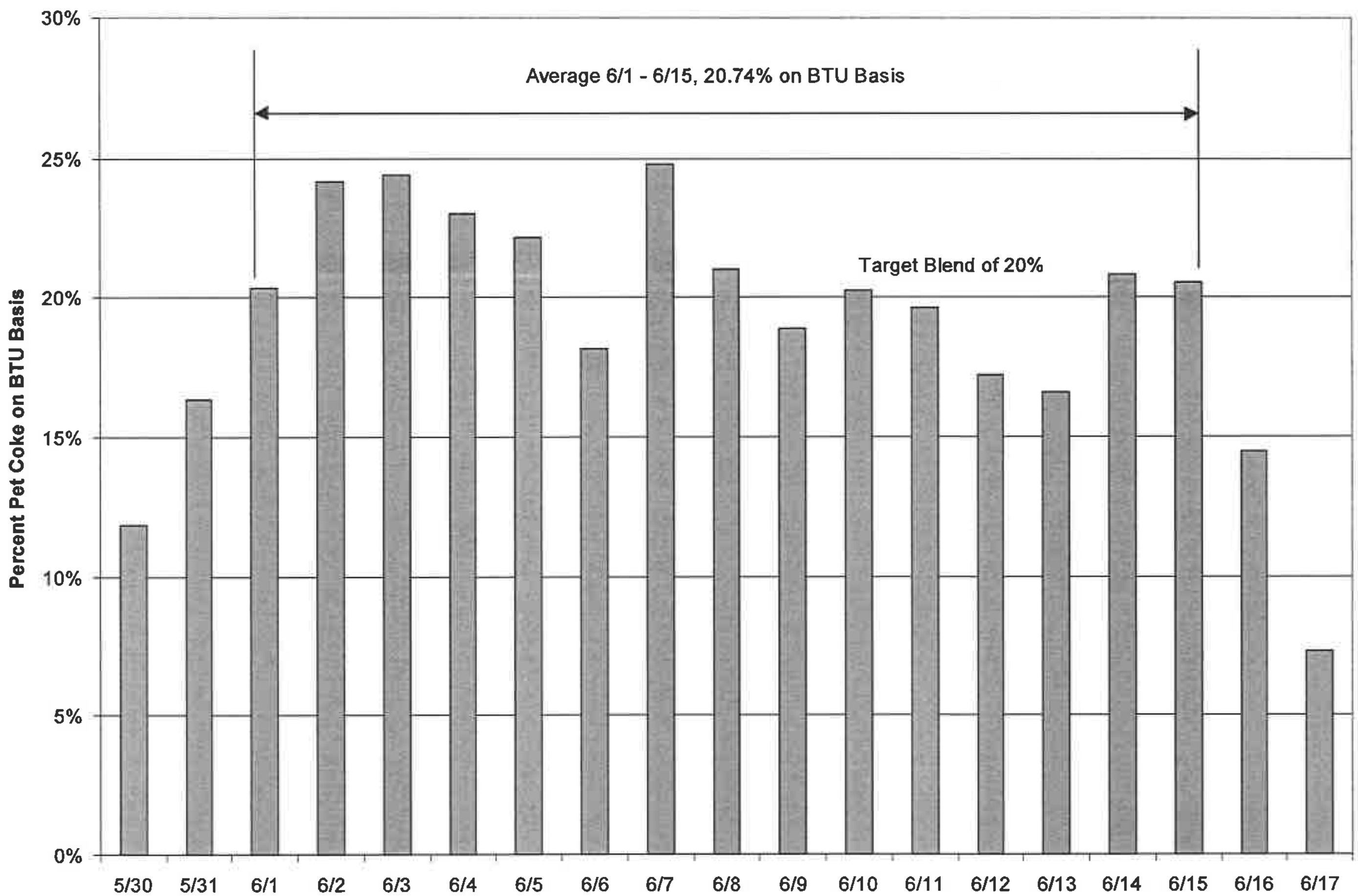

Figure V-1

Section VI - Environmental Concerns and Limitations

1.0 Definition of Applicable Environmental Terms

For this report, we will only be dealing with the air quality emissions concerns of the IPP-Radian Ammonium Sulfate Project. Before beginning the discussion, it would be well to define a couple of terms relative to environmental permitting:

Prevention of Significant Deterioration (PSD) Review: The Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act (CAA) are found in 40 CFR 52.21. The state of Utah has been delegated authority to administer the PSD program within the State and the EPA retains the authority to independently enforce the PSD rules if it determines that the State is not doing so. A PSD review would occur if there was a "Major Modification" in which there was any physical change or change in the method of operation that would result in a significant net emissions increase of any pollutant subject to regulation under the CAA. The EPA has defined that "Significant" means any increase in the rate of emissions that would equal or exceed 40 tons per year for either NO_X or SO_2.

New Source Performance Standard Review (NSPS) Review: Any physical change in or change in the method of operation which increases the amount of any air pollutant emitted by such source or which results in the emission of any air pollutant not previously emitted triggers the applicability of the New Source Performance Standard (NSPS). There is no threshold limit for which an NSPS review might be required. Any increase caused by the change or modification will trigger the review.

Best Available Control Technology (BACT): Best Available Control Technology (BACT) is just like its name suggests, the best technology available for control of a pollutant. For SO_2 emissions, BACT is generally considered to be scrubbers; however, some efficiency improvements to the IPP scrubbers may be required if either a PSD or NSPS review is completed. BACT for NO_X is generally considered to be Selective Catalytic Reduction (SCR).

2.0 Results of Test Burn on Environmental Compliance

2.1 SO_2 Emissions and Environmental Review

The results of this test burn clearly indicate that pet coke cannot be burned at IPP with the current SO_2 scrubbing equipment without some improvements or modifications. Any pet coke as fuel would surely result in an annual increase of greater than 40 TPY. However, if the Ammonium Sulfate Project proceeds, modifications would be made to the scrubbers that would theoretically improve scrubber efficiency to ensure no increase in annual emissions. The conversion of the scrubbers to operate with ammonia instead of limestone is such a radical shift from the current operating method, it would be difficult to argue that it is not a major modification and would therefore require PSD/NSPS review. If the modified scrubbers are able to achieve and maintain efficiencies in the 98-99% range, it could be argued that they are BACT no matter what the actual emissions maybe.

Since no actual testing has been done with a modified scrubber module, many questions remain about the environmental impacts of the conversion. We have been assured by Radian that the required removal efficiencies are attainable, but we have no hard data to support that premise. They have also assured us that the scrubber can be operated at a pH that will almost totally eliminate ammonia vapors in the flue gas. A modified scrubber module should be tested before a final environmental assessment of the project is completed.

2.2 NO_X Emissions and Environmental Review

The increased NO_X emissions observed during the test burn would definitely trigger a PSD/NSPS review which would most likely require BACT for NO_X control. It is not the intent of this report to cover the economic benefits of this project, however, the cost of installing SCR technology for both IGS units is estimated to be $150,000,000 to $200,000,000, which if done strictly for the ammonium sulfate project, would make it economically unfeasible. The EPA has proposed that all coal fired generating stations meet a lower NO_X emissions rate sometime around the year 2007. When these regulations are finalized and if they result in IPP having to install SCR technology anyway, the economics of the project may change and become more viable. The only hope for proceeding with the project at this time is to find a pet coke that will not raise NO_X emissions.

Section VII - Conclusions

Based on the results of the test, the following conclusions can be made:

1. A 20% blend of pet coke on a BTU basis resulted in a 24% increase in NO_X emissions. The increase was probably the result of a 24% increase in the blended fuel nitrogen content, but that may not be the total cause. Other factors in the pet coke chemistry including volatile species, oxygen, and moisture content may dominate the formation of NO_X during combustion. A different pet coke with a lower nitrogen content may or may not result in lower NO_X emissions.

2. Redistributing the air flow in the furnace by opening the secondary air damper on the out-of-service burner row lowered NO_X emissions by approximately 10%. Excess oxygen was held constant during the change. This resulted in a slight increase in ash LOIs, but no other serious operational impacts were noted.

3. Adjusting excess air in the furnace down to 2% along with opening the out-of-service burner row lowered NO_X emissions approximately 17%. NO_X emissions with these two operational adjustments was close to, but still exceeded the baseline period. Operation at 2% excess air is not prudent for long term operation of the IGS boilers. Normal variations in instrument calibrations and controls could result in a dangerous situation of insufficient air for complete combustion.

4. Ash LOIs increased with the amount of pet coke in the fuel. IPP ash would not be suitable for use as a high grade cement additive if pet coke is burned as a fuel. This would result in a loss of approximately $1,500,000 of revenue to IPSC.

5. Pulverizer fires did not increase with the addition of pet coke.

6. Pulverizer fineness was approximately the same with the addition of pet coke.

7. Boiler slagging and fouling appeared to be the same for both the baseline and pet coke combustion periods. No boiler slagging and fouling problems would be expected if pet coke is used as a fuel.

8. SO_2 emissions out the stack increased 150% due to the high sulfur content in the pet coke. Scrubber efficiency will have to improve if pet coke is used as a fuel.

9. Sodium formate was used as a buffering agent for this test. Sodium formate did not increase removal efficiency while pet coke was burned. The sodium formate did help to maintain the removal efficiency close to the same level as the baseline period.

10. Scrubber efficiencies probably did not improve due to flue gas "sneakage" in the

modules which is allowing flue gas to pass through the scrubber without contacting the reagent sprays. The "sneakage" is probably around the vessel walls and could be improved by installing a shelf around the module walls to direct the air flow into the middle of the modules.

11. None of the testing to date has done anything to prove or disprove that the conversion of the scrubber to produce ammonium sulfate will actually work or that it will remove the necessary quantities of SO_2 from the flue gas. If this project proceeds, one module should be modified to operate with ammonia to verify that the process will work as intended.

12. Baghouse differential pressures remained constant with either coal or the coal-pet coke blend as the fuel. Some problems have been experienced since the test was completed with a high LOI (33%) ash plugging the feeder equalizing lines. Since the problem is only on Unit 1, there is speculation that the plugging is the result of the pet coke, but it is not conclusive.

13. Background levels of SO_2 in the scrubber building did not increase as the amount of SO_2 in the flue gas from the pet coke increased.

14. There were many rail car unloading difficulties with the pet coke. Some were caused by the condition of the Union Pacific cars used for transportation and some were caused by the characteristics of the pet coke. The time to unload a pet coke was six hours compared to only two hours for coal. These problems will have to be resolved for this project to proceed.

15. No roll back of pet coke on the conveyor belts was observed. This was a different type of pet coke than was used for the first test.

16. Fugitive dust from the pet coke during unloading and stack out was similar to that of coal. The current IPSC fugitive dust plan and equipment would probably be sufficient to control pet coke dust.

17. The pet coke was successfully blended with a reasonable degree of accuracy using the Active Reclaim Rotary Plows. The target blend was 20% on a BTU basis and the average from June 1 to June 15 was 20.74%.

18. Some problems were experienced with pet coke getting accidently mixed into the coal during the baseline period. There was no physical separation between the two piles and the pet coke frequently sluffed into the coal reclaim area. This would have to be resolved either with a separating wall or a different reclaim and storage area for the pet coke before this project could proceed.
19. The increased NO_X emissions by burning pet coke would result in an NSPS/PSD review of IPP emissions. This would most likely result in the required installation of

BACT for NO_X which is SCR's. The cost of installation of SCR's for IGS would be $150,000,000 to $200,000,000.

20. The high sulfur content of pet coke makes it impossible to be burned at IPP as an alternate fuel without modifying the scrubbers to increase efficiency. The increased SO_2 emissions would trigger an NSPS/PSD review that would most likely require the installation of scrubber improvements.